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# PATENT SPECIFICATION

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## (54) DEGASSING TREATMENT OF LIQUID

(71) We, THE BRITISH PETROLEUM COMPANY LIMITED, of Britannic House, Moor Lane, London, EC2Y 9BU, a British Company, do hereby declare the invention,

5 for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the removal of an undesirable gas from a liquid, more particularly to the deoxygenation of water.

It is often necessary to inject water into oil reservoirs for various purposes, e.g.

10 (a) to increase the rate of water inflow through injection wells (injectivity improvement),

(b) to aid tertiary oil recovery from oil production wells by displacing crude oil on a large scale in the reservoir, and

15 (c) to remove pore-blocking water drops from oil bearing porous reservoirs in the vicinity of a production well.

With marine or coastal oil reservoirs, i.e., reservoirs having an abundant, readily available, supply of sea water, it is clearly an advantage to make use of this.

20 Sea water, however, contains significant quantities of dissolved oxygen, about 10 ppm at 10°C, which renders it unsuitable for use in its raw state because of its corrosive action and its encouragement of bacterial growth. These defects can be reduced by de-oxygenation but equipment currently used for such a purpose, bubble cap towers, is bulky and costly. Bulk is, of course, a particularly serious disadvantage insofar as offshore production fields are concerned.

25 According to the present invention there is provided a method for the removal of an undesirable gas from a liquid in which it is dissolved which method comprises contacting the liquid co-currently with an inert gas in a static mixer as hereinafter defined to displace the undesirable gas by the inert gas, passing the resulting mixture of liquid containing dissolved inert gas, free inert gas and undesirable gas to a cyclone separator and recovering liquid of higher quality.

30 By a static mixer we mean a device which

promotes controlled turbulent mixing of two or more initially separate streams to ensure efficient mixing without the use of moving parts.

35 Suitable inert gases include nitrogen, natural gas and components thereof, e.g., methane. The term "inert" is used in respect of the gas with reference to the materials of the system, suitably special steels and plastics, and the liquid and is not limited to the elements of Group 0 of the Periodic Table. These would be suitable, but in most cases availability and cost will exclude them from practical consideration.

40 It may be advisable to carry out the degassing in a number of stages, possibly three, using a number of static mixers connected in series with a separation between each stage.

45 The inert gas-liquid flow ratios for each stage are suitably in the range 10:1 to 1:10 scf gas/ft<sup>3</sup> liquid.

50 Suitable static mixers are sold by Sulzer Bros. Winterthur, Switzerland. These are of modular construction which allows some versatility in design.

55 Static mixers are known for use in mass transfer under turbulent conditions but it is surprising that they have been found effective for a transfer which normally occurs by a diffusion mechanism.

60 The method is particularly suitable for the deoxygenation of water, including sea water.

65 By the process of the present invention it is possible to reduce the oxygen content of water from about 10 ppm to about 0.05 ppm or lower.

70 The invention is illustrated with reference to Figures 1 and 2 of the accompanying drawings and the following Example.

75 With reference to the drawings, Figs. 1 and 2 are flow sheets of different embodiments of the invention.

80 In Fig. 1 influent water containing oxygen is fed by line 1 to a first stage static mixer 2. Gas is also supplied to the mixer through the line 3. Effluent from the mixer 2 is passed to cyclone separator 4 through the

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- line 5. Separated gas is withdrawn from the cyclone 4 through the line 6. Water flows to the second stage static mixer 8 through the line 7 where it is mixed with a further supply of gas through the line 9. Effluent from the mixer 8 is passed to a second stage cyclone separator 10 through the line 11. Separated gas is withdrawn from the cyclone 10 through the line 12.
- Water flows to the third stage static mixer 13 through the line 14 where it is mixed with a further supply of gas through the line 15. Effluent from the mixer 13 is passed to a third stage cyclone separator 16 through the line 17. Separated gas is withdrawn from the cyclone through the line 18 and de-oxygenated water is recovered from the line 19.
- In this embodiment separate streams of fresh gas are supplied to each mixer. In this embodiment, if desired the water may be pumped between any or all of the stages to reduce the overall pressure drop in the system. This is also beneficial in that the efficiency of deoxygenation increases as the applied pressure is reduced.
- In the embodiment of Figure 2 the deoxygenation gas passes in one continuous stream through the system in a direction which overall is countercurrent to the direction of flow of the water, although in each mixer the flow is co-current. This has the advantage that for a given throughput of liquid a smaller system and less gas is required, or alternatively for a given size a larger throughput of liquid is possible, or alternatively for a given throughput of liquid and volume of gas fewer stages may be used.
- Influent water containing oxygen enters the system through the line 21 and inert gas through the line 28. The water meets gas recycled from the second stage cyclone separator 25 through the line 29 and passes to the first stage static mixer 22. Effluent from the mixer 22 is passed to the first stage cyclone separator 23 through the line 30. Separated gas is exhausted from the cyclone 23 through the line 31.
- Water from the cyclone 23 flows to the second stage static mixer 24 through the line 32 where it is mixed with gas recycled from the third stage cyclone separator 27 through the line 33 and passes to the second stage static mixer 24. Effluent from the mixer 24 is passed to the second stage cyclone separator 25 through the line 34. Separated gas is recycled from the cyclone 25 to the first stage static mixer 22 through the line 29.
- Water from the cyclone 25 flows to the third stage static mixer 26 through the line 35 where it is mixed with fresh gas entering the system through the line 28 and passes to the third stage static mixer 26. Effluent from the mixer 26 is passed to the third stage cyclone separator 27 through the line 36. Separated gas is recycled from the cyclone 27 to the second stage static mixer 24 through the line 33 and deoxygenated water is recovered through the line 37.
- In this embodiment either the liquid stream must be pumped between stages or the gas stream compressed between stages to maintain the flows in the desired direction.
- Example*
- The following Example illustrates the first stage of the embodiment described with reference to Fig. 1.
- Water containing 10.4 ppm of oxygen was passed through a  $\frac{1}{4}$  inch static mixer at a rate of 30 l/min with a co-current flow of nitrogen also at the rate of 30 l/min. The effluent stream was then passed through a cyclone separator 2 inch in diameter and separated into gas and water streams. The oxygen content of the effluent water was reduced to 1.6 ppm.
- WHAT WE CLAIM IS:—**
1. A method for the removal of an undesirable gas from a liquid in which it is dissolved which method comprises contacting the liquid co-currently with an inert gas in a static mixer to displace the undesirable gas by the inert gas, passing the resulting mixture of liquid containing dissolved inert gas, free inert gas and undesirable gas to a cyclone separator, and recovering liquid of higher quality. 90
  2. A method according to claim 1 wherein the inert gas is nitrogen, natural gas or a component thereof. 95
  3. A method according to either of the preceding claims wherein the undesirable gas is oxygen. 100
  4. A method according to any of the preceding claims wherein the liquid is sea water. 105
  5. A method according to any of the preceding claims wherein the removal of the undesirable gas is carried out in a number of stages. 110
  6. A method according to claim 5 wherein the number of stages is 3. 115
  7. A method according to any of the preceding claims wherein the inert gas/liquid flow ratio for the or each stage is in the range 10:1 to 1:10 standard cubic feet of gas per cubic foot of liquid. 120
  8. A method as hereinbefore described with reference to the Example. 120
  9. Products whenever separated by a method according to any of the preceding claims. 120

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1 SHEET

COMPLETE SPECIFICATION  
*This drawing is a reproduction of  
the Original on a reduced scale*

FIG.1

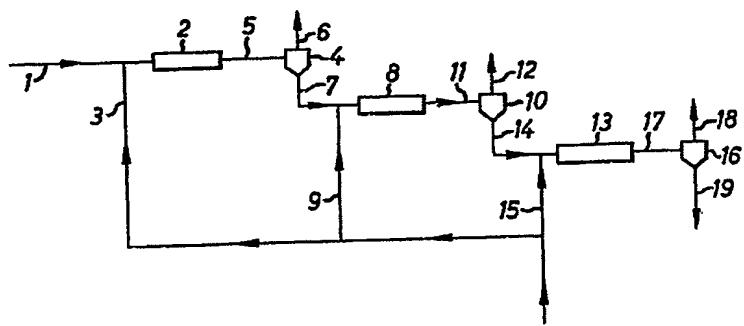
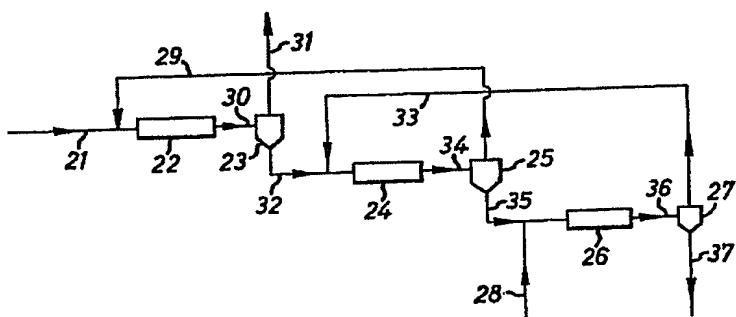


FIG.2



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